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The Making of a DoD Acquisition Lead System Integrator (LSI)

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14. ABSTRACT
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Preface & Acknowledgements

Welcome to our Tenth Annual Acquisition Research Symposium! We regret that this year it will be a “paper only” event. The double whammy of sequestration and a continuing resolution, with the attendant restrictions on travel and conferences, created too much uncertainty to properly stage the event. We will miss the dialogue with our acquisition colleagues and the opportunity for all our researchers to present their work. However, we intend to simulate the symposium as best we can, and these *Proceedings* present an opportunity for the papers to be published just as if they had been delivered. In any case, we will have a rich store of papers to draw from for next year’s event scheduled for May 14–15, 2014!

Despite these temporary setbacks, our Acquisition Research Program (ARP) here at the Naval Postgraduate School (NPS) continues at a normal pace. Since the ARP’s founding in 2003, over 1,200 original research reports have been added to the acquisition body of knowledge. We continue to add to that library, located online at www.acquisitionresearch.net, at a rate of roughly 140 reports per year. This activity has engaged researchers at over 70 universities and other institutions, greatly enhancing the diversity of thought brought to bear on the business activities of the DoD.

We generate this level of activity in three ways. First, we solicit research topics from academia and other institutions through an annual Broad Agency Announcement, sponsored by the USD(AT&L). Second, we issue an annual internal call for proposals to seek NPS faculty research supporting the interests of our program sponsors. Finally, we serve as a “broker” to market specific research topics identified by our sponsors to NPS graduate students. This three-pronged approach provides for a rich and broad diversity of scholarly rigor mixed with a good blend of practitioner experience in the field of acquisition. We are grateful to those of you who have contributed to our research program in the past and encourage your future participation.

Unfortunately, what will be missing this year is the active participation and networking that has been the hallmark of previous symposia. By purposely limiting attendance to 350 people, we encourage just that. This forum remains unique in its effort to bring scholars and practitioners together around acquisition research that is both relevant in application and rigorous in method. It provides the opportunity to interact with many top DoD acquisition officials and acquisition researchers. We encourage dialogue both in the formal panel sessions and in the many opportunities we make available at meals, breaks, and the day-ending socials. Many of our researchers use these occasions to establish new teaming arrangements for future research work. Despite the fact that we will not be gathered together to reap the above-listed benefits, the ARP will endeavor to stimulate this dialogue through various means throughout the year as we interact with our researchers and DoD officials.

Affordability remains a major focus in the DoD acquisition world and will no doubt get even more attention as the sequestration outcomes unfold. It is a central tenet of the DoD’s Better Buying Power initiatives, which continue to evolve as the DoD finds which of them work and which do not. This suggests that research with a focus on affordability will be of great interest to the DoD leadership in the year to come. Whether you’re a practitioner or scholar, we invite you to participate in that research.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the ARP:

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- Director, Acquisition Career Management, ASN (RD&A)
- Program Executive Officer, SHIPS
- Commander, Naval Sea Systems Command
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- Army Contracting Command, U.S. Army Materiel Command
- Office of the Assistant Secretary of the Air Force (Acquisition)
- Office of the Assistant Secretary of the Army (Acquisition, Logistics, & Technology)
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James B. Greene Jr.
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System of Systems Management

The Making of a DoD Acquisition Lead System Integrator (LSI)

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Abstract

The complexity of developing and acquiring weapons systems continues to increase due to highly integrated system architectures, rapid technology evolution, and emergence of highly diverse set of missions. The imperatives of system-of-systems (SoS) integration and interoperability (I&I) further complicate the system acquisition process. These challenges continue to frustrate completing the acquisition of systems within time and budget goals.

The DoD has commonly assigned the role of the lead system integrator (LSI) to a prime contractor. This is fraught with many issues related to conflict of interest, performance, and defining clear roles and responsibilities (especially the inherent role of government). The DoD has indicated that, in some cases, the LSI responsibilities should migrate back to the DoD.

In this paper, we discuss the roles of the LSI, where DoD acquisition skills may need to be strengthened to perform as the LSI, and discuss methods and tools to do so. This paper is a result of multi-year discussions and research with a major Naval Systems Command to find a path to faster time-to-market and higher levels of interoperability and integration of our weapons system acquisitions.

Introduction

What is a lead system integrator (LSI)? Although a broader concept than its simple acronym, commonly, the role of the LSI has been turned over to industry in the form of a prime contractor, or team of contractors, hired by the federal government to execute a large, complex, system-of-systems (SoS), defense-related acquisition programs (Grasso, 2007). The need for an LSI is often associated with the acquisition of an SoS or a constituent system to an SoS. SoS programs acquire a collection of various platforms (e.g., ground vehicles, aircraft, and ships) that are to be linked together so as to create a larger, integrated overall system (Lane, 2006).

LSIs are further categorized based on their system development capabilities and responsibilities. Section 805 of the National Defense Authorization Act of Fiscal Year 2006 (2005) defines these two types of LSIs as

1. "Lead system integrators with system responsibility" prime contractors who develop major systems that are not expected at the time of the contract award, as determined by the Secretary of Defense, to perform a substantial portion of the work on the system and major subsystems.
2. "Lead system integrators without system responsibility"—contractors who perform acquisition functions that are closely associated with inherently governmental functions in the development of a major system. LSIs, regardless of type, are subject to the same rules as other federal contractors.

In recent years, the LSI responsibility has been awarded to industry for major DoD acquisitions. However, this has led to conflict-of-interest complications resulting in revised law stating, "No entity performing lead systems integrator functions in the acquisition of a major system by DoD may have any direct financial interest in the development or construction of any individual system or element of any system of systems" (Defense Authorization Act for Fiscal Year 2006, Section 807). As a result, several of the major contractors have divested into companies focused separately on systems integration and product development. An example is Lockheed Martin, where "Lockheed Martin's decision to divest the business was based on the U.S. Government's increased concerns regarding perceived conflicts of interest" (The SI Organization, 2010).

Due to recent failures in some major DoD acquisition programs (examples in GAO, 2007), the DoD has made the decision to use an LSI endure more scrutiny by, in some cases, requiring certification by the Committees on Armed Services for both the Senate and the House (OSD, 2007). This has led some to conclude that to reduce complexities and risks associated with the use of contractors as the LSIs, the DoD should consider (Grasso, 2007):

- prohibiting the use of private-sector LSIs in future acquisition programs;
- reducing the possible need for private-sector LSIs by building the defense civilian and military acquisition workforces back up, and having the DoD assume the role of the LSI, and requiring that DoD manage all SOS programs; and
- implementing the recommendations of the Gansler Commission on improving the acquisition workforce (U.S. Army, 2007).

The following discussion begins with the premise that the DoD concurs with the recommendations above and desires to bring more LSI responsibilities "in house," in particular, engineering responsibilities. Some of the major systems commands are exploring such a transformation to bring systems to the DoD more quickly while attaining higher levels of interoperability (Young, 2010). If the DoD acquisition community wants to make such a transformation to retain more inherently governmental responsibilities for major system acquisitions, what needs to be done to fortify the systems engineering (SE) workforce skills, SE methods, and SE tools to enable taking on the larger role of the LSI? We use Figure 1 as a context diagram throughout (blue is our focus).

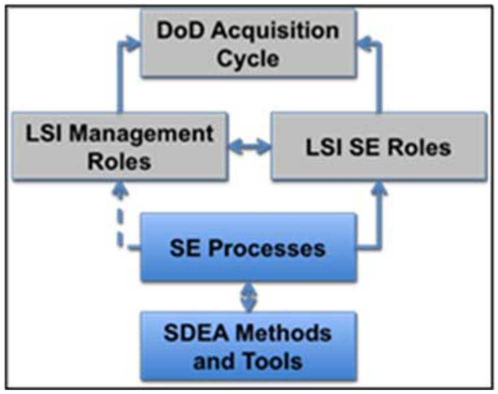

Figure 1. LSI Systems Engineering and Management Roles Are Supported by Systems Engineering Processes, Methods, and Tools

In our previous research (Montgomery, Carlson, & Quartuccio, 2012), we focused on how SE tools could be applied to DoD acquisition SE methods. We introduced a model-base, SE-inspired approach named System Definition-Enabled Acquisition (SDEA) in that research and discussed how SDEA could be instrumental for LSI SE success. What follows extends that previous SE tools perspective to the role of the LSI SE as a result of ongoing research with Naval Air Systems Command (NAVAIR).

Problem Definition and Research Questions

The Defense Authorization Act for Fiscal Year 2006 (Section 807) provides emphasis on the importance that the lead systems engineer on a DoD acquisition be an experienced government employee. Additionally, the DoD ASD(R&E) chief systems engineer, Stephen Welby (2012) summarized the imperatives for DoD SE as follows:

> As the complexity of our systems has increased, so has the need for effective systems engineering throughout the life cycle. We face challenges in implementing robust systems engineering processes, from requirements identification and analysis through technology and architecture selection and assessment, analysis and coordination of complex system design, development, and execution …. We are now increasingly focused on addressing early-acquisition phases including requirements definition, development planning, and early acquisition systems engineering support.

Finally, as stated in a report sponsored by Welby (Systems Engineer Research Center [SERC], 2010), "existing systems engineering tools, processes, and technologies poorly support rapid design changes or capability enhancements within acceptable cost and schedule constraints."

Problem Statement

The background and guidance presented in the previous section leads to our investigation, focused by the following problem statement: The DoD does not have adequate SE methods, processes, workflows, and/or tools that support the expansive role of the LSI in major weapons systems acquisitions.

Research Questions

The associated research questions that we have been investigating in order to resolve our problem statement include the following:

- What are key DoD acquisition challenges for the LSI?
- What are the key LSI roles and attributes?
- What is the current state of DoD LSI maturity?
- What SE methods are prime candidates to improve upon to support LSI?
- How can MBSE/SDEA be applied to the LSI?

LSI Challenges

Regardless of the government/contractor ownership of LSI SE responsibilities, the challenges to current acquisitions are diverse, not necessarily new, and are discussed as follows (derived from Montgomery et al., 2012).

Complex System Acquisition

The current DoD acquisition process (see Figure 2), as specified in DoD 5000, WSARA, and a long heritage of acquisition experience, is based on the acquisition of stand-alone systems. Today’s system acquisitions are more co-dependent on the development of other complex systems in an SoS environment. This requires a higher level of coupling between system engineering and the acquisition process to support SoS, as well as the need for higher levels of LSI support.

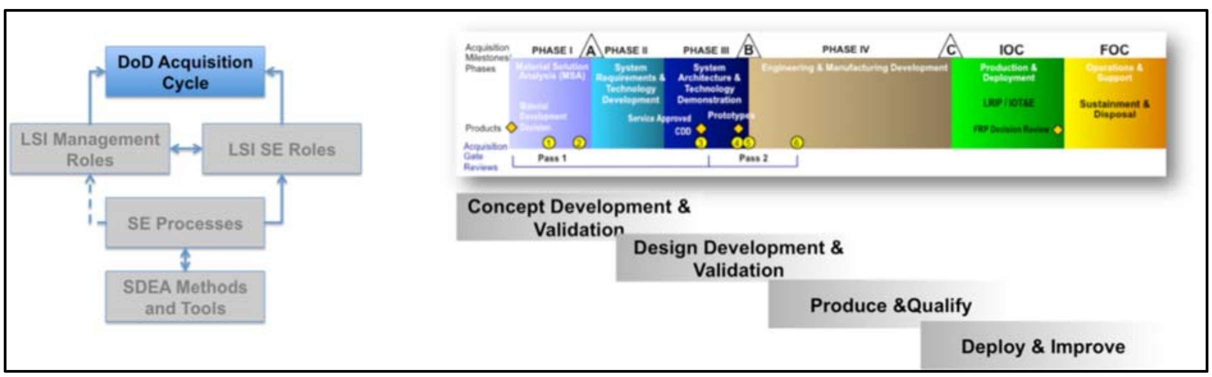

Figure 2. DoD 5000 Acquisition Process

A problem that continues to frustrate this acquisition timeline and increase program costs is both system complexity and SoS interoperability. Many acquisitions are the integration of several systems that are being acquired and developed independently and for their own purposes. This SoS method presents a new and interesting level of complexity for system engineers because system engineers rarely have the opportunity to affect the design of these co-dependent systems. The functionality, interfaces, operational objectives, and intended system environments all provide a challenge to ensuring that the SoS can be integrated successfully while producing new emergent behaviors that are predictable and satisfy the user needs. Couple all of this complexity and SoS realities to the existing system engineering methods, practices, principles, organization behaviors, and workforce skills, and the need for SDEA methods and tools becomes clearer to resolve many of the following challenges.

Acquisition Timeliness

Acquisitions are too slow-to-market. Acquisition schedules are often document-driven and technical review-driven processes and non-adaptive to changing or emergent requirements. DoD 5000 emphasizes prototypes early in acquisition, requiring a tightly coupled engineering system to meet engineering goals, objectives, and requirements. The LSI SE needs to be diligent to ensure pre-planned programmed improvements (P3Is) are enabled and that tools provide enduring design data.

Acquisition Process

The Acquisition process is not LSI design-driven. The DoD 5000 acquisition process is oversight-driven and document-driven and designed such that government engineers provide the oversight while the contractors provide the content. It is likely that DoD 5000 will ultimately have to be revised to define a process more aligned to the government providing LSI SE direction. An example would be to exploit a process that that could be streamlined as a result of the government and user community retaining more LSI SE activities and direct engagement with the development of the baseline in lieu of merely reviewing the progress of the contract.

System Complexity

LSI engineering capabilities do not always support design and acquisition of highly complex systems. Simple systems and complex systems proceed through the acquisition process essentially the same. The role of the LSI, however, is more applicable for the needs of complex systems with a significant emphasis on defining the interaction of systems along with robustness of the system solution. This will require a dramatically different way of defining the LSI engineering process and how it integrates with the program management processes. An example is employment of tools and methods to provide the ability to assess SoS performance and emergent system behaviors in a quantifiable manner. Currently, the ability to predict, manage, and control such emergent behaviors can be elusive.

Integration and Interoperability

Systems often fail at integration or do not interoperate effectively. Successful integration of systems, especially SoS, is challenged by functional gaps and overlaps among the systems' complex interfaces and a large number of internal and external system interfaces. SoS integration also demands the interoperability among these systems, as well as the interoperability outside of the system for other systems that are codependent. The LSI needs SE tools and methods that define and manage risks associated with these critical functions and interfaces.

Total Ownership Costs

Prediction and control of total ownership costs (TOC) is difficult. The acquisition cost incurred during the development cycle is only a fraction of the total ownership cost of any system. The LSI needs to have very detailed, predictable, and repeatable behavior modeling of both the acquired system and external systems in order to accurately predict and control TOC.

Engineering Workforce

The veteran engineers are rapidly retiring and not being replaced with engineers with commensurate experience. The system design process and SE tools need to provide high levels of repeatability and quantifiability that is less dependent on engineering judgment and more dependent on metrics that provide a highly refined engineering solution. Given that many veteran engineers are retiring, there is a need to provide system design-driven methods to a younger engineering community. A system is needed that also provides project-to-project consistency and repeatability.

Systems Engineering Attributes and Roles of an LSI

LSI Attributes

Not all DoD acquisitions need to be managed by an LSI. Many systems can be acquired with small teams where complexity and risk are relatively easy to manage. The following is a list that includes attributes of program and system designs where the need for an LSI may be more imperative (partially derived from Loudin, 2010):

- Program importance and span of impact—high risk, large cost, or expansive interoperability impacts to the enterprise
- System or SoS complexity—large-scale complexity with a large number of high-consequence risks, external SoS interfaces and interactions, and high likelihood of unanticipated, negative emergent behaviors
- Stakeholder relationships—Collaborative versus command-and-control contractor/government/fleet user interactions are necessary
- Organization agility is required to organize around acquisition (versus the obverse)
- DoD determines that ownership of critical data and/or DoD reuse of critical IP is mandated
- “National teaming” is required to ensure enterprise-level SoS issues are intrinsic to system success
- Acknowledgement and acceptance of higher system design and acquisition risks
- Rapid identification and adaptation of emergent opportunities are essential
- Strong integration leadership and control is required
- Low barriers to entry for technology and innovation need to be established and maintained throughout the life cycle
- Disciplined and rigorous standards demanded for integration of other systems into the enterprise

LSI Roles

The roles of the LSI are similar to the roles of any SE or system integrator (SI). The primary difference is the span of design and integration authority that persists throughout the system acquisition and/or complete life cycle. The following are a sampling of the LSI roles that are more expansive than traditional SE/SI:

- Design: Act as the primary designer (sometime referred to as the “design agent”). Design includes system and SoS designs. Roles include conceptual design, architectural design (operational, functional, physical, interface, qualification), and integration and qualification designs.
- Source selection: Responsible for providing solicitation packages, reviewing and evaluating proposals, and selecting and awarding the contract to component, subsystem, system, or product provider. Component-level solicitation has often been assigned to prime contractors.

- Subcontractor selection: Survey, vetting, and selection of providers of components or services. Component-level selection has often been assigned to prime contractors.
- Supplier chain management: Engagement within the domains of hardware and software configuration item selection, sources of supply, and manufacture.
- Trade-off studies: Conduct of objective trade-off studies and analysis of system challenges, risks, and opportunities.
- System baseline management: Definition, control, and management of system design baselines, configuration management, and realized configurations.
- Rigorous, multi-system definition and management of interfaces, taxonomy, system structures, and so forth.
- Coordinator (and funder) of contributing research.
- End-to-end span of authority and control for baseline control and management of the system design, development, integration, qualification, and deployment.
- Qualification (“V&V”): Ultimate responsibility for developmental (verification), operational (validation), and acceptance qualification success.
- Sustainment/suitability: Responsible for sustainment and suitability design of the system and impact analysis of SoS sustainment strategies.

Current State of the DoD LSI

How do many engineering organizations operate today in DoD acquisition? There have been many strains on DoD manpower reductions over recent years, and the result has been to depend heavily on contractors to do the “heavy lifting” in many engineering domains. Although the government retains many subject-matter experts (SMEs), these highly skilled staff are senior, retiring at a rapid rate, and are stretched thin. The larger and more complex the project, the more likely the government has decided to use a large prime or LSI contractor.

The different roles of engineering involvement are shown in Figure 3, spanning from performing the role of the “buyer” for simple systems to the role of “integrator” when acquiring complex systems. (We put forth these role titles just to provide reference; they are not formally accepted throughout DoD). As can be seen, the engineering tasks (requirements engineering, design, etc.) become more expansive as the role approaches that of the LSI (integrator). The roles close to red (bottom of the list) are associated with complex acquisitions. Our assumption is that the government has been performing in the yellow band of this chart during recent years. As previously stated, contractors have been more likely to be assigned the majority of engineering duties as the systems became more complex.

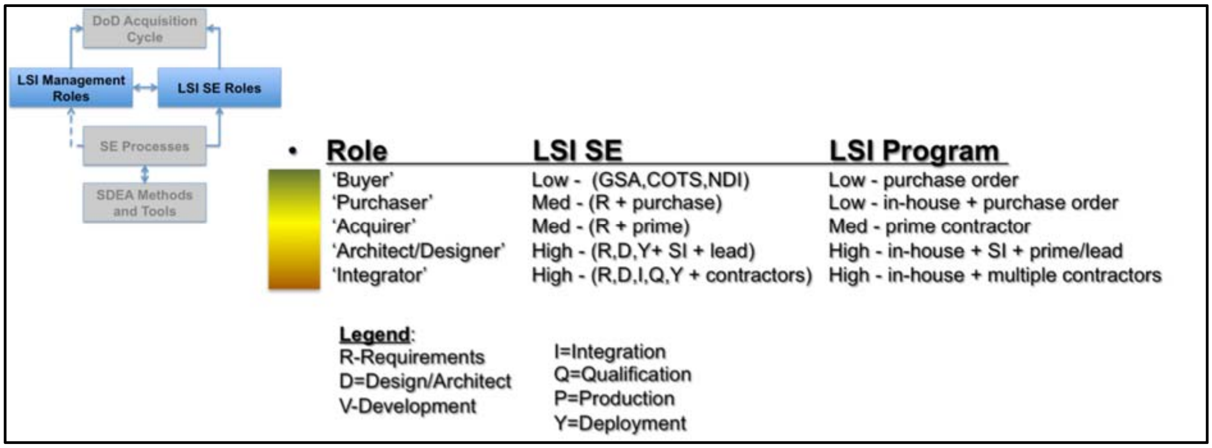

Figure 3. The Engineering Involvement of the DoD Acquirer Becomes More Expansive for Complex ("Integrator" Role) Systems as Compared to Simple ("Buyer" Role) Systems

Figure 4 depicts "traditional" versus "LSI" contractor/government engineering span of authority across the DoD acquisition cycle. The top portion (a) is a typical acquisition cycle that spans from system concept to deployment. The middle portion (b) indicates that the traditional government levels of engineering effort are maximum at the early and latter stages of the acquisition, with the contractor design, production, and integration in the middle. The lower portion (c) of the diagram posits that, if the government is the LSI, the government performs more of the design and integration activities, and the contractor shifts to a more "manufacturing" role. Although there could be many variations on this LSI theme, what is important to note is that the area under the curve represents the government level of effort. Some refer to his role as the "design agent." In the LSI case, this level of effort is more expansive than today and requires new methods, practices, and tools to support the government engineer.

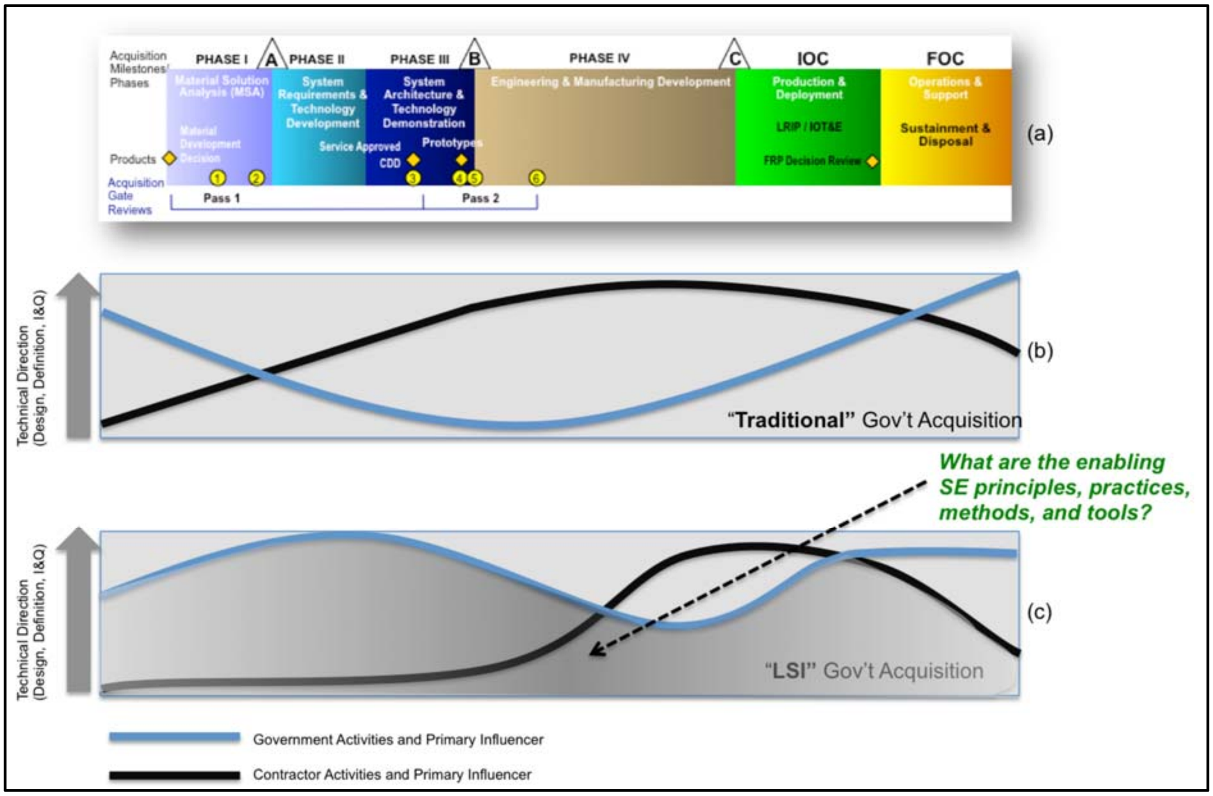

Figure 4. The LSI Roles for the Government—(c) Compared to (b)—Will Require Greater Methods, Practices, and Tools to Achieve Work of the Increased "Area Under the Curve"

Another perspective is to try to assess where the "maturity" of the government engineering community (writ large) is today and how it needs to be enhanced. Figure 5 puts forward a non-scientific assessment of where that maturity may be (dotted line). The colors align with Figure 3 and shows that the current DoD acquisition workforce performs comfortably as a "buyer" and "purchaser", often at the "acquirer" level, but has yet regularly perform at the "architect/designer" or "integrator/LSI" role. The graph shows that, as the government makes the transition to the upper right of the graph, the engineering and programmatic span of authority must, necessarily, increase for the government and decrease for the contracting community.

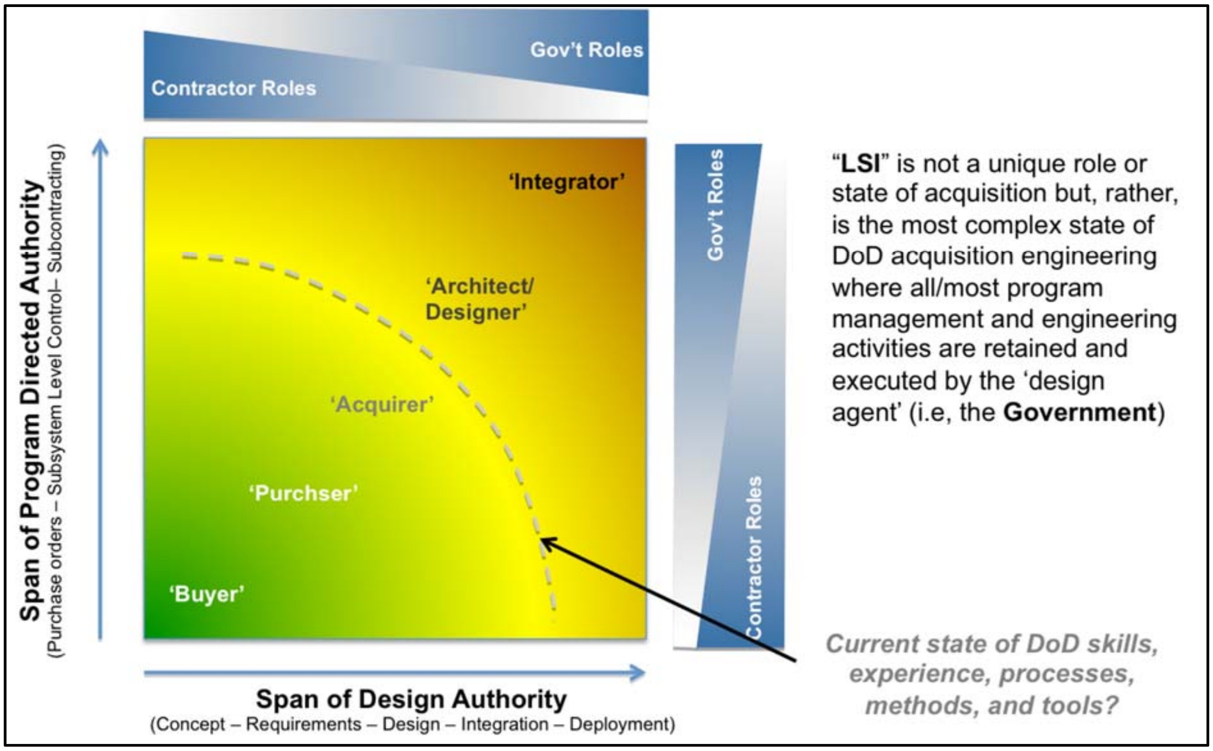

Figure 5. Increasing Role of Government Engineering Toward "Integrator" Will Involve Reducing Span of Design and Programmatic Authority for the Contractor

Systems Engineering Methods Supporting LSI

There are probably very few new fundamental principles and essential activities that are required for the LSI; however, the depth and ownership of SE activities are greater and more enduring. In order for the DoD to move to the upper right-hand corner of Figure 5, additional SE practices, methods, and tools need to be enhanced. A representative SE activity set typically employed throughout any system acquisition cycle is shown in Figure 6. Although we can anticipate that many, if not all, of the activities will be impacted by taking on the role of the LSI, our interviews have indicated that the *early* application of discipline SE practices and methods create the greatest and most significant positive impact to reducing risk and increasing system success. Figure 6 shows that the dark blue activities are the most likely candidates to receive attention for workforce development and to apply SDEA concepts and tools.

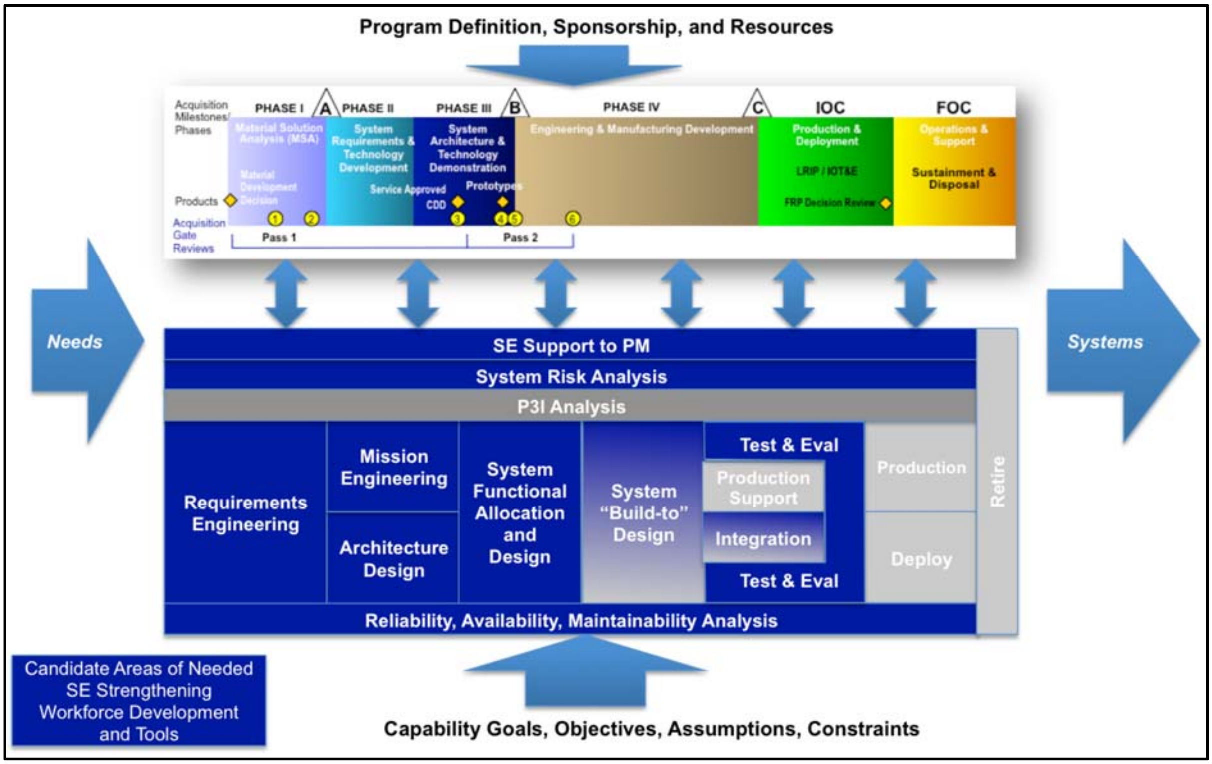

Figure 6. Systems Engineering Activities Need Strengthening to Expand Role as an LSI

Although still formative, the SE activities shown may focus upon general concepts of the following:

- Concept development—Eliminating disconnects between originator needs and acquisition system requirements.
- Design—Inexperience, insufficient or missing tools, and weak methods.
- Integrative methods—Organizational teaming, SoS awareness, standards, priorities, technical incentives.
- Development—DoD (LSI) and contractor common models and tools.
- Integration—Gaps in cross-discipline skills and experience, lack of facilities, weak methods, lack of jointness.
- Test and evaluation—Gaps in attaining a system that is mature and ready for test.

System Definition-Enabled Acquisition (SDEA) System Concept

Top-Level Concept

The top-level SDEA concept is shown in Figure 7. The intent is that SDEA supports all of the SE activities in Figure 6 in a quantitative and repeatable manner. The SDEA system comprises system definition, modeling, and analyses that provide repeatable and quantifiable designs. The SDEA system is to provide a data-driven system definition and model-driven SE approach that supports LSI SE and design.

The SDEA system is synergistic with the program definition, system definition, supportability definition, and system production. Note that all of these activities support baseline development and control. Program definition leads to system definition and the handoff contract (documents) associated with system capabilities and top-level performance goals.

Additionally, program definition leads to documentation and agreements that set in motion long-term supportability strategies and activities, such as logistics, training and manpower, and long-term supply chain strategies. The SDEA system supports both system definition in a very repeatable and quantifiable manner, as well as providing clear detail and system reliability and supportability metrics to the support system associated with the acquisition.

Finally, system production depends on precise SDEA system definition in order to proceed to production of the system in preparation for deployment.

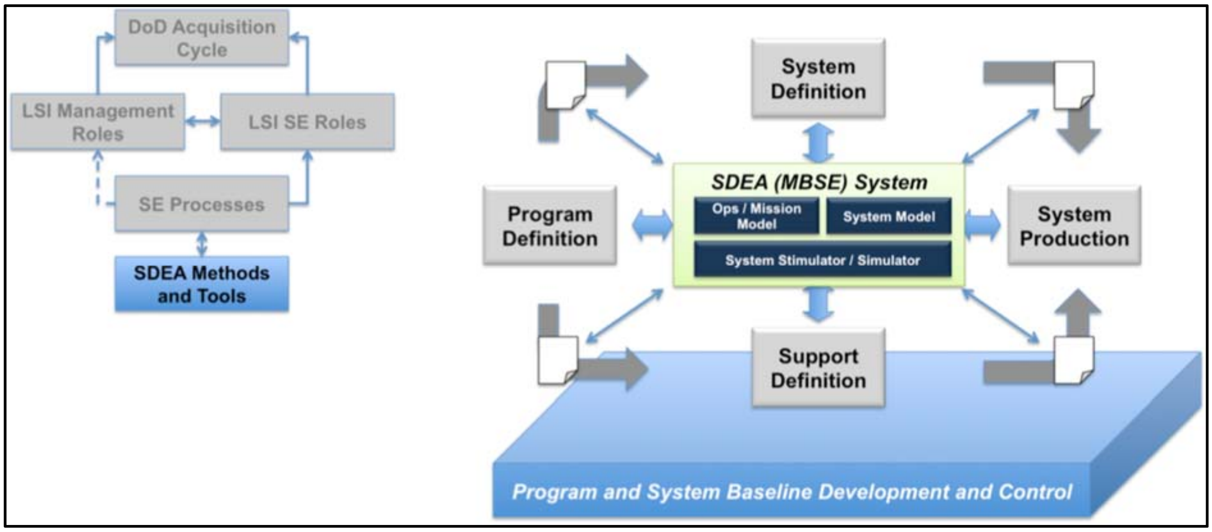

Figure 7. SDEA Provides Central Engineering System Support to Acquisition
(derived from Montogmery et al., 2012)

Summary

Past performance by contractors performing what some now believe are inherently governmental acquisition engineering functions during major DoD weapon system acquisition has proven problematic, in some cases. Legislation and policy is moving DoD to consider transforming its engineering role for major systems (especially SoS) to that of the LSI. The DoD acquisition workforce methods, practices, and tools, however, need to be upgraded and enriched to achieve this transformation. We believe that the integration of model-based system engineering (MBSE) tools through an SDEA method is key to supporting the higher levels of SE design disciplines, analyses, and baseline control, and will contribute to quicker time-to-market and lower integration and interoperability risks for future weapons systems.

In summary:

- An LSI is needed where high system complexity, high risks, or SoS integration/interoperability are present.
- DoD acquisition organizations are exploring taking on more of the LSI roles.
- DoD acquisition practices need fortifying to cope with the more expansive levels of SE.

- SE methods need reinforcing, and SE tools (e.g., SDEA) need to be acquired and integrated into the workflow with capability to provide
    - early and strong SE application (pre-milestone A),
    - data-driven design support tools,
    - repeatable and quantifiable system design analyses,
    - persistent (multi-year/multi-system) design data repository,
    - SoS interoperability and integration analyses, and
    - operational, qualification (V&V), suitability, and sustainability design/analysis support.

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